Maternal Weight:
An opportunity to impact infant mortality in North Carolina

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Abstract

Preliminary data for 2008 revealed that North Carolina's infant morality rate ranked 44th highest amongst the 50 U.S. states (N.C. Healthy Start Foundation, 2010). Addressing issues with maternal weight may offer an opportunity to impact adverse pregnancy outcomes.

This report focused on two objectives to: (1) determine what adverse pregnancy outcomes could be impacted by addressing weight issues in women of childbearing age and (2) analyze the scope of overweight women of childbearing age in North Carolina.

The most commonly noted adverse pregnancy outcomes associated with increased prepregnancy BMI were hypertensive disorders, gestational diabetes mellitus, c-section, and macrosomia. When compared to women entering pregnancy with a normal or low BMI, preeclampsia, gestational diabetes mellitus, and gestational hypertension exhibited the highest risk-ranges for women with a high prepregnancy BMI. For many of the adverse pregnancy outcomes, the greater the deviation of the prepregnancy BMI from normal, the greater the risk for adverse pregnancy outcomes. Based on 2007 Pregnancy Risk Assessment Monitoring System (PRAMS) data, maternal characteristics associated with increased risk of overweight in North Carolina include age, race, income, WIC recipient, and Medicaid recipient.

Healthcare providers (HCP's) report the following common barriers to discussing weight issues with patients: lack of time to counsel, lack of knowledge/confidence, perception of patient motivation/compliance, insurance or Medicare reimbursement issues, and lack of belief the treatment would be effective. Addressing these barriers

may support HCP efforts to improve maternal prepregnancy BMI and subsequently improve pregnancy outcomes.

Four additional recommendations for applying this information to impact maternal and child health needs in North Carolina surfaced though this research: (1) encourage use of standard BMI categories within clinical practice and research; (2) support studies about appropriate weight gain for women entering pregnancy with an increased BMI; (3) create and implement overweight/obesity prevention and management programs in North Carolina focused on preconception and the identified high risk subgroups; and (4) ameliorate HCP identified barriers.

Introduction

Infant mortality rates directly reflect a population's health and well-being. Historically, the United States' (U.S.) infant mortality has ranked surprisingly high among industrialized nations. Although improvements in U.S. infant mortality have occurred over the years, the country's world ranking continues to fall. With the most recent international ranking in 2004, the U.S. infant mortality ranked 29th, down from 23rd in 1990 and 12th in 1960 (MacDorman & Mathews, 2010). Because of the lack of progress in this area, the Healthy People 2010 objective of reducing fetal and infant mortality is being maintained as a Healthy People 2020 objective (Office of Disease Prevention & Health Promotion, U.S. Department of Health and Human Services, 2009).

Successfully addressing this issue requires a firm grasp of factors associated with infant mortality. Research identifies a multitude of factors contributing to these high infant mortality rates, including maternal health, quality of and access to medical care, socioeconomic conditions, and public health practices (MacDorman & Mathews, 2010). Of these factors, maternal heath has earned a recent position in the North Carolina spotlight as public health experts examine how a woman's preconception health impacts the health of the infant.

In looking at women's preconception health, issues with maternal weight deserve special attention. Concerns about pregnancy outcomes in overweight mothers have been present since 1945 (Odell, 1945). The Institute of Medicine and National Research Council reported in *Weight Gain during Pregnancy: Reexamining the Guidelines* (Institute of Medicine and National Research Council, 2009) that "[e]vidence from the scientific literature is remarkably clear that prepregnancy body mass index

(BMI) is an independent predictor of many adverse outcomes of pregnancy. As a result women should enter pregnancy with a BMI in the normal weight category." (p. 7)

Yet, obesity has reached epidemic proportion in the U.S. and the number of women entering pregnancy overweight or obese has also increased (Kim, Dietz, England, Morrow, & Callaghan, 2007). Kim et al.'s (2007) examination of obesity in nine U.S. states from 1993-2003 found that prepregnancy obesity increased from 13% in 1993-1994 to 22% in 2002-2003 (see Figure 1). Essentially, one-fifth of American women were obese when they become pregnant as of 2003, a 70% increase within one decade. Analyzing the increases from each of the nine states separately revealed an increase ranging from 45% to 105% for individual states. Yeh and Shelton (2005) also analyzed trends in prepregnancy BMI in the U.S. from 1999-2003. This research demonstrated a 9.2% increase in overweight and obese women during the study period (Yeh & Shelton, 2005). Both Kim et al. (2007) and Yeh and Shelton (2005) analyzed subgroups of their study populations and found consistent increases within nearly all of the subgroups examined, including age, race/ethnicity, education level, insurance type, and parity. Developing effective interventions for many of the factors associated with infant mortality has proven quite challenging, yet weight control offers promise as a method of reducing adverse pregnancy outcomes (MacDorman & Mathews, 2010).

Preliminary data for 2008 revealed that North Carolina's infant mortality rate ranked 44th highest amongst the 50 United States (N.C. Healthy Start Foundation, 2010). By improving their infant mortality rate, North Carolina therefore holds an opportunity to impact the infant mortality rate of the entire country by decreasing the rate overall. Since research suggests that high prepregnancy BMI poses additional risk

for adverse pregnancy outcomes, it then becomes important to examine the scope of the overweight/obesity problem in North Carolina. How many of North Carolina's women of child-bearing age are affected by overweight/obesity? Is the rate substantial enough to justify North Carolina utilizing its resources for interventions related to this issue?

Methods

The objectives of this study are therefore to (1) determine what pregnancy outcomes could be impacted by addressing weight issues in women of childbearing age and (2) examine the scope of overweight women in the population of women in North Carolina of child-bearing age. Two analytical approaches were taken to achieve these objectives: a comprehensive literature review of prepregnancy BMI-related pregnancy outcomes and a review of state-level population and surveillance data pertaining to women of child-bearing age in North Carolina.

The literature review of prepregnancy BMI-related pregnancy outcomes employed Google Scholar and PubMed to identify relevant research articles. Search terms utilized included prepregnancy, prenatal, pregravid, body mass index, birth outcomes, pregnancy complications, overweight, and obese. The titles and abstracts of the articles produced by the searches were reviewed for relevance. Only original research articles were retained. Articles prior to 1998 were excluded, as were articles specific to multiple birth pregnancies and those not focused on prepregnancy weight and BMI. Articles targeted to only one outcome were also excluded from review (e.g., studies designed to specifically examine preeclampsia). The reference lists from the remaining articles provided additional resources which were examined for eligibility.

All eligible articles were explored for the increased risk of adverse pregnancy outcomes between various BMI prepregnancy categories. Examining the analysis methods utilized for each of the included studies proved valuable in determining whether the results were adjusted for pertinent confounders. The adjusted odds ratios were examined when available, and only values noted as statistically significant (odds ratio confidence interval not including one) were included in this report.

Although BMI has been well established as the preferred method for measuring adiposity, classifying the level of adiposity by BMI range varies tremendously from one source to another. The World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH) standards are consistent; yet, the literature reveals that researchers apply a wide variety of BMI ranges (Table 1). To compensate for this limitation, general trends in the data were examined rather than drawing specific conclusions for any one BMI category. The WHO BMI categories were utilized for analysis of the eligible articles since the studies were conducted in a number of countries. Although the WHO categories provide subgroups within the obesity category, none of them is identified as morbidly obese. This category was included for review when presented by the study author. When category names differed from the WHO categories, the category was assigned to the WHO range which it most closely matched.

Adverse pregnancy outcomes were defined as any unfavorable complication or condition potentially related to pregnancy. They were categorized according to who was proximally impacted (mother or fetus) and maternal outcomes were further

subdivided by the timing of their occurrence (during pregnancy, during labor or delivery, after birth).

In examining the scope of overweight in North Carolina's females of childbearing age, the target population first needed to be quantified. To accomplish this, the North Carolina Office of State Budget and Management (OSBM) population estimates and projections were reviewed. These statistics are based on census data and supplemented with population information collected annually from North Carolina municipalities, counties and military bases. Data for women of childbearing age (15 through 44 years of age) was extracted from OSMB population estimates.

Subgroups of North Carolina's women of childbearing age were then examined to determine which subgroups held the highest risk for a BMI outside of the normal range. The 2007 Pregnancy Risk Assessment Monitoring System (PRAMS) survey results were utilized for this analysis. PRAMS data is state-specific and population-based. It captures maternal attitudes and experiences before, during, and shortly after pregnancy. PRAMS data collection occurs through a mailed survey/questionnaire or through a telephone survey. The maternal characteristics of obesity among North Carolina females of childbearing age were arranged according to WHO BMI standards with overweight and obese groups combined (i.e., overweight ≥25.0 BMI). The proportions provided in each subgroup were adjusted to reflect the entire population of North Carolina women having a live birth.

To truly compare where the highest risks lie, odds ratios were calculated based on the crude sample numbers provided. Armitage and Berry's methods were applied for calculating both the odds ratios and confidence intervals (Armitage & Berry, 1994).

The odds of overweight among women exposed to the variable was compared to the odds of overweight among the non-exposed. The referent group was set as the maternal characteristic variable with the lowest calculated risk for overweight.

Results

The literature review regarding prepregnancy BMI-related pregnancy outcomes produced seven articles meeting inclusion criteria. Six articles utilized normal BMI category as the reference range (Abenhaim, Kinch, Morin, Benjamin, & Usher, 2007; Baeten, Bukusi, & Lambe, 2001; Bhattacharya, Campbell, Liston, & Bhattacharya, 2007; Doherty, Magann, Francis, Morrison, & Newnham, 2006; Jensen et al., 2003; Rosenberg, Garbers, Chavkin, & Chiasson, 2003), and one study used underweight as the null (Cnattingius, Bergstrom, Lipworth, & Kramer, 1998). The characteristics of the seven eligible research articles were examined (see Table 2). Two of the studies were conducted in the U.S. (Baeten et al., 2001; Rosenberg et al., 2003), and one in each of the following counties: Australia (Doherty et al., 2006), United Kingdom (Bhattacharya et al., 2007), Sweden (Cnattingius et al., 1998), Canada (Abenhaim et al., 2007), and Denmark (Jensen et al., 2003). The cohort sizes for the studies ranged from 2,459 to 213,208.

Tables 3 and 4 note the frequency of adverse pregnancy outcomes for prepregnancy BMIs which were outside of the normal range and Table 5 lists the odds ratios and corresponding confidence intervals.

Increased Prepregnancy BMI: Maternal Outcomes During Pregnancy

For women with an increased prepregnancy BMI, increased risk for five maternal outcomes during pregnancy were identified: antenatal admission (Abenhaim et al.,

2007), eclampsia (Baeten et al., 2001), gestational diabetes (Abenhaim et al., 2007; Baeten et al., 2001; Cnattingius et al., 1998; Doherty et al., 2006; Rosenberg et al., 2003), gestational hypertension (Abenhaim et al., 2007; Bhattacharya et al., 2007; Cnattingius et al., 1998; Doherty et al., 2006), and preeclampsia (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007; Cnattingius et al., 1998; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003). Of these, gestational diabetes, gestational hypertension, and preeclamsia were the three most commonly noted.

Gestational diabetes. Five of the seven studies demonstrated a statistically significant increase in risk for gestational diabetes (Abenhaim et al., 2007; Baeten et al., 2001; Cnattingius et al., 1998; Doherty et al., 2006; Rosenberg et al., 2003). The gestational diabetes odds ratios for individual BMI categories ranged from 1.3 to 2.71 for overweight women (Abenhaim et al., 2007; Baeten et al., 2001; Doherty et al., 2006; Rosenberg et al., 2003), 2.4 to 6.5 for obese women (Abenhaim et al., 2007; Baeten et al., 2001; Doherty et al., 2006; Rosenberg et al., 2003) and 4.1 to 5.2 for morbidly obese women (Abenhaim et al., 2007; Baeten et al., 2001; Rosenberg et al., 2003). Multiple studies also reported an increasing risk with each increase in BMI category (Abenhaim et al., 2007; Baeten et al., 2001; Doherty et al., 2006; Rosenberg et al., 2003).

Preeclampsia All seven articles identified an increase in risk for preeclampsia in women with elevated prepregnancy BMI (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007; Cnattingius et al., 1998; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003). Abenhaim et al. (2007) found that when compared to those entering pregnancy with a normal BMI, overweight women demonstrated a 1.28

times greater risk, obese women a 3.65 times greater risk, and morbidly obese women a 5.26 times greater risk. The other six research articles supported this finding that risk of preeclampsia increased with increasing BMI category (Baeten et al., 2001; Bhattacharya et al., 2007; Cnattingius et al., 1998; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003). While Cnattingius (1998) did not provide odds ratios for preeclampsia, he did note that "[t]he rate of preeclampsia increased with increasing body-mass index, as follows: lean women, 1.8 %; normal women, 2.5 %; overweight women, 4.2 %; and obese women, 7.0 %" (p. 148).

Gestational hypertension Cnattingius (1998) found that 2.8 % of lean women experienced gestational hypertension compared to 10.2 % among the obese women. Other studies found that the odds of gestational hypertension were 1.5 to 2.6 times as likely in overweight women as those with a normal prepregnancy BMI (Abenhaim et al., 2007; Bhattacharya et al., 2007; Doherty et al., 2006). The odds ratios for obese and morbidly obese were 2.01 to 7.3 (Abenhaim et al., 2007; Bhattacharya et al., 2007; Doherty et al., 2006) and 2.77 to 3.1(Abenhaim et al., 2007; Bhattacharya et al., 2007), respectively.

Increased Prepregnancy BMI: Maternal Outcomes during Labor and Delivery

An increased risk of four adverse maternal outcomes during labor and delivery were identified for women with an increased prepregnancy BMI. These outcomes were c-section (emergency and non-emergency) (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003), induction of labor (Abenhaim et al., 2007; Bhattacharya et al., 2007; Doherty et al., 2006; Jensen et al., 2003), perineal tear (Doherty et al., 2006), and shoulder

dystocia (Abenhaim et al., 2007). Of these, c-sections and induction of labor were the most common adverse outcomes experienced.

C-Sections Increased risk for c-section was noted in six of the seven articles (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003). Bhattacharya (2007) separated elective c-sections from emergency c-sections. Doherty et al. (2006) analyzed all c-sections together and then stratified those performed under emergency circumstances. All other odds ratios for the remaining studies were for c-section, regardless of indication.

When comparing c-sections regardless of indication, those receiving a c-section were 1.3 to 1.6 times as likely to be overweight (Abenhaim et al., 2007; Baeten et al., 2001; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003), 1.8 to 2.7 times as likely to be obese (Abenhaim et al., 2007; Baeten et al., 2001; Doherty et al., 2006; Jensen et al., 2003; Rosenberg et al., 2003), and 2.7 to 2.92 times as likely to be morbidly obese (Abenhaim et al., 2007; Baeten et al., 2001; Rosenberg et al., 2003) than those who entered pregnancy with a normal BMI. The odds ratios for elective c-sections in overweight and obese women were not statistically significant in Bhattacharya's study; however, morbidly obese women demonstrated increased risk for elective c-section (OR 3.1) which was statistically significant (Bhattacharya et al., 2007). Emergency c-sections were 1.5 times as likely for overweight women, 2 to 4.57 times as likely for obese women, and 2.8 times as likely for morbidly obese when compared to women with normal prepregnancy BMI (Bhattacharya et al., 2007; Doherty et al., 2006).

Induction of Labor Bhattacharya et al.(2007), Doherty et al. (2006), and Jensen et al. (2003) all reported increased risk for induction of labor among women with above normal prepregnancy BMI. The odds of labor induction for overweight women ranged from 1.3 to 1.5 among these studies. Obese women were 1.8 to 3.22 times as likely to be induced and morbidly obese women were 1.8 times as likely.

Increased Prepregnancy BMI: Maternal Post-Partum Outcomes

Poor postpartum outcomes significantly increased due to increased prepregnancy BMI included postpartum hemorrhage (Abenhaim et al., 2007; Bhattacharya et al., 2007; Doherty et al., 2006) and wound complications and infections (Abenhaim et al., 2007). Of these, postpartum hemorrhage was most commonly reported, with statistical significance in three of the seven studies.

Postpartum Hemorrhage Abenhaim et al. (2007) and Doherty et al. (2006) revealed increasing risk of postpartum hemorrhage as a woman's BMI increased. Postpartum hemorrhage was 1.26 and 1.55 times as likely in overweight women (Abenhaim et al., 2007; Doherty et al., 2006) and 1.5 and 1.71 times as likely in obese women (Bhattacharya et al., 2007; Doherty et al., 2006). Morbidly obese women were 3.14 times as likely to experience postpartum hemorrhage (Abenhaim et al., 2007). While Bhattacharya et al. (2007) did not show increasing risk with increasing BMI, all three BMI categories demonstrated increased risk compared to women with normal prepregnancy BMI (OR 1.1, 1.5, 1.3).

Increased Prepregnancy BMI: Fetal/Neonatal Outcomes

Adverse outcomes for the fetus were also identified when women's prepregnancy BMI are above normal. An increased risk was observed for late fetal death and

macrosomia; macrosomia was the more commonly noted of the two. Macrosomia was defined as infants with a birth weight >4kg or infants >90th percentile of growth (large for gestational age (LGA)). This outcome was noted in five of the seven studies (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007; Jensen et al., 2003; Rosenberg et al., 2003) with the odds of macrosomia increasing with increasing BMI in all but one (Jensen et al., 2003) study.

Three studies reported an increased risk of preterm delivery associated with prepregnancy weight although not for all BMI categories (Abenhaim et al., 2007; Baeten et al., 2001; Bhattacharya et al., 2007). Of note, these studies also defined preterm differently.

When Cnattigius et al. (1998) stratified results by nulliparous vs. parous, late fetal death was found to be statistically significant among all groups of nulliparous women with increased BMI groups. A statistically significant association was only observed for morbidly obese parous women.

Babies of women with an above-normal prepregnancy BMI experienced increased risk for the following outcomes after birth: poor Apgar scores or requiring resuscitation (Abenhaim et al., 2007; Doherty et al., 2006), early neonatal death (nulliparous) (Cnattingius et al., 1998), neonatal hypoglycemia (Doherty et al., 2006), and Neonatal Intensive Care Unit (NICU) admission (Abenhaim et al., 2007; Rosenberg et al., 2003). NICU admissions in Rosenberg et al.'s (2003) study were not statistically significant when adjusted for other pregnancy complications.

Decreased Prepregnancy BMI

In the studies examined, pregnancies beginning with a below-normal maternal prepregnancy BMI only demonstrated increased risk for poor fetal/neonatal outcomes. The most commonly noted outcomes were related to fetal growth. Infants with intrauterine growth restriction were 1.33 to 1.8 times as likely to be born to women with decreased prepregnancy BMI (Abenhaim et al., 2007; Doherty et al., 2006), low birth weight and very low birth weight were 1.4 to 1.7 times as likely (Bhattacharya et al., 2007; Rosenberg et al., 2003), and small for gestational age were 1.54 times as likely (Abenhaim et al., 2007; Cnattingius et al., 1998). Preterm labor and delivery were also outcomes noted more commonly for women underweight prior to pregnancy when compared to those with a normal prepregnancy BMI.

Scope of Overweight in North Carolina's Females of Child-bearing Age

North Carolina OSBM data estimates North Carolina's population of females of childbearing age was 1,870,330 as of July 01, 2007. (Table 7 displays the population by age group and county.) Women of childbearing age represented 20.7% of North Carolina's population, which was estimated to be 9,041,821. The counties with the highest number of women of childbearing age were: (1) Mecklenburg; (2) Wake; (3) Guilford; (4) Forsyth; (5) Cumberland; (6) Durham ; (7) Buncombe; (8) Gaston; (9). New Hanover; and (10) Union.

Table 8 shows 2007 PRAMS survey results for maternal characteristics of obesity among North Carolina females of childbearing age. In terms of age, one third to nearly one half of each age group was overweight. More Hispanic women were overweight compared to non-Hispanic, but these differences were small (47.6% Hispanic vs. 42.8% non-Hispanic). Black women had the highest percentage of

overweight women of the three race categories examined, with 53% being overweight. Women with an income of $25,000 to $49,999 had the highest percentage of overweight (51.4%), followed by ≤14,999 (49.9%), 15,000-24,999 (43.9) and ≥50,000 (35.8%). 50.6% of Supplemental Nutrition Program for Women, Infants, and Children (WIC) recipients were overweight while only 37.6% of those women who were not receiving WIC were overweight. A slightly higher percentage of women on Medicaid were overweight (47.7% vs. 38.6%). Nearly half of the infants born weighing under 2500 grams and half of the infants born weight at least 2500 grams were to overweight mothers.

Comparing the calculated odds ratios and corresponding confidence intervals revealed only a few statistically significant categories associated with overweight (see Table 9). Comparison of age groups identified that women at least 20 years of age were at greater risk for overweight than women less than 20 years of age. Within the race subgroup, black women of childbearing age were 1.74 times as likely to be overweight than white women. Two income levels demonstrated statistically significant increases in risk for overweight women: 14,999 or less (OR 1.6) and 25,000 to 49,000 (OR 1.56). WIC recipients were at increased risk (OR 1.49) of being overweight in comparison to those not receiving these services. Likewise, female Medicaid recipients were 1.37 as likely to be overweight as those not receiving WIC.

Discussion

Women with increased prepregnancy BMI had the most adverse pregnancy outcomes and highest risk ranges compared to those with normal and decreased prepregnancy BMI. For increased BMI, outcomes with highest risk-ranges were

preeclampsia, gestational diabetes mellitus, and gestational hypertension. The most commonly noted outcomes for increased BMI were hypertensive disorders (gestational hypertension and preeclampsia), gestational diabetes mellitus, c-section, and macrosomia.

The studies reviewed consistently demonstrate that deviation from normal prepregnancy BMI increases maternal and fetal morbidity. This literature review has also established that this problem is not limited to obesity, as adverse pregnancy outcomes for underweight, overweight, obese and morbidly obese women were also observed. The data support the importance of maintaining a normal BMI in managing maternal and fetal morbidities. Not only does deviation beyond the normal BMI range increase risk for adverse pregnancy outcomes, for many outcomes, the greater the deviation, the greater the risk.

Comparing the risks for outcomes between BMI categories revealed a protective association for some conditions and particular BMI categories. For example, Abenhaim et al. (2007) reported a statistically significant lower risk of preeclampsia, gestational hypertension, and gestational diabetes mellitus among women with a below normal prepregnancy BMI. According to Doherty et al. (2006), women who enter pregnancy with a low BMI were 0.9 times less likely to have a retained placenta than women entering pregnancy at a normal BMI and 0.44 times less likely to have their neonate experience hypoglycemia; these findings were statistically significant. An increased BMI revealed decreased risk for low birth weight (LBW) and small for gestational age (SGA) (Baeten et al., 2001).

The results of this literature review were consistent with other research which did not meet the eligibility criteria for the review (e.g., other literature reviews and condition specific studies). However, there are many concerns about performing detailed comparisons between reports on the impact of maternal weight on pregnancy outcomes. Primarily, the studies reviewed differed in their definitions of BMI-categories, the choice of control groups, time and length of the study periods, choice of exclusion criteria, and characteristics of the population studied. Additionally, some of the outcomes identified may be interrelated. For example, gestational diabetes mellitus increases the risk that an infant will be born large for gestational age, there may be relationship between labor induction and c-section, and macrosomia may become an indication for c-section. While most studies included in this review adjusted risks for potential confounders, the potential confounders for each outcome varied across studies. For example, when Cnattingius et al. (1998) stratified nulliparous and multiparous women, it appeared that parity may be a risk factor for certain adverse outcomes such as early neonatal death; none of the other studies controlled for parity. Not only were adjusted odds ratios only available for some studies, one study did not even provide crude odds ratios for all outcomes mentioned.

It is also important to note that the odds ratios for Doherty et al.'s (2006) obese category tend to be higher for statistically significant outcomes. This may be due to the inclusion of all women with a >30 prepregnancy BMI. While this matches the WHO BMI categories, the other studies reviewed further subdivided obese and morbidly obese for analysis.

In additional to the previously mention limitation related to varying definitions of BMI categories, one study used weight categories rather than BMI categories (Rosenberg et al., 2003). Also, not all studies included analysis of underweight, and Cnattingius (1998) utilized lean as the reference range.

Variation also existed in the method by which BMI was determined. Several studies (Abenhaim et al., 2007; Baeten et al., 2001; Bodnar, Ness, Markovic, & Roberts, 2005) computed BMI based on self-reported weight and height. Self-reported weight is commonly underestimated, especially by individuals of higher weight (Baeten et al., 2001). This makes the reported data for these studies subject to reporter bias and subsequent misclassification. These biases may lead to an underestimation of association between exposure variables and outcomes.

The limited availability of research that fit the inclusion criteria for this review served as yet another limitation. Studies excluded from this analysis contain more expansive lists of adverse outcomes. (Table 6 provides examples of adverse outcomes noted in studies excluded from this analysis.) However, a more complex analysis would be required to compare the results of those studies included with those excluded from this review.

Based on the analysis of the 2007 PRAMS data, it appears that North Carolina's interventions should target women at least 20 years of age, with an income of less than $50,000, WIC and Medicaid recipients, and Black women. OSMB data is helpful in identifying the counties with the largest populations in the targeted age categories. Additional research is required to identify counties where the other variables of interest are most prevalent.

One of the primary limitations of this analysis was that the odds ratios were not adjusted for potential cofounders. Adjusted odds ratios strengthen the validity and generalizability of study results. A second limitation lies in the small sample sizes for some of the subpopulations, which limit the statistical power of the study. A third limitation is the reliance of PRAMS on self reported information. Reporter bias is likely and may impact the accuracy of the analysis results.

Although the majority of patients believe that they should lose weight, most HCPs do not diagnose or develop management plans for most overweight/obese patients (Bardia, Holtan, Slezak, & Thompson, 2007; Budd, Mariotti, Graff, & Falkenstein, 2009; Potter, Vu, & Croughan-Minihane, 2001). Research shows that patients want more help with weight management than they are getting from their primary care providers (Potter et al., 2001). With the BMI-related adverse pregnancy outcomes identified and the scope of North Carolina's obesity problem in women of childbearing age better defined, it therefore becomes important to examine how healthcare providers can be supported in addressing this issue with patients.

The literature identifies several HCP barriers to diagnosis, treatment and management of overweight and obesity. Bardia et al.'s (2007) provides a comprehensive list of HCP barriers. These barriers commonly appeared in other literature as well (Boyle, Lawrence, Schwarte, Samuels, & McCarthy, 2009; Dunkley, Stone, Patel, Davies, & Khunti, 2009; Forman-Hoffman, Little, & Wahls, 2006; Galuska, Will, Serdula, & Ford, 1999; Lutfiyya et al., 2008; O'Donnell, Brown, & Dastani, 2006; Power, Cogswell, & Schulkin, 2006; Ruelaz et al., 2007; Waring, Roberts, Parker, & Eaton, 2009). The most commonly reported HCP barriers were lack of time to counsel

and lack of knowledge/confidence. Other barriers noted in multiple studies included perception of patient motivation/compliance, insurance or Medicare reimbursement issues, lack of belief the treatment will be effective, limited support resources, environmental milieu, fear of embarrassing patient, and forgetting to talk about it or document it/ complacency. (Table 10 shows Bardia et al.'s (2007) comprehensive barrier list and the frequencies with which each barrier was noted in the other literature examined.) Barriers in Bardia et al.'s (2007) "HCP factors" category appeared in the literature as the most commonly reported HCP barriers. This reinforces the importance of interventions supporting HCP management of overweight/obesity, as diagnosis of the condition serves as the strongest predictor of a management plan (Bardia et al., 2007). Training and education of HCPs on this issue may ameliorate lack of knowledge, instill greater confidence, and provide HCPs with information about effective overweight/obesity treatment. HCPs would also benefit from tools to measure patient motivation for change.

Conclusions and Recommendations

Through the process of meeting this report's objectives, four primary recommendations for using maternal weight to reduce infant mortality surfaced. First, encourage use of standard definitions of BMI categories within clinical practice and research. Monitoring this issue and the effectiveness of interventions is difficult without a well established, standard baseline.

Second, support studies about the appropriate amount of pregnancy weight gain for women who enter pregnancy with BMI above normal. Additional research is needed

including more complex analysis of existing data about the impact of prepregnancy weight on adverse pregnancy outcomes.

Third, create and implement overweight/obesity prevention and management programs. Budd et al. provides the following general program recommendations: include pre and post-testing; focus on raising awareness of the etiology of obesity; identify the implications of weight loss efforts; and provide information regarding bias-free interventions. Galtier-Dereure et al. (2000) suggests the following for programs targeted to HCPs: record BMI as part of standard physical; diagnose and treat overweight/obesity when identified; preconception counseling; take metabolic and vascular disorders into account when counseling about birth control methods; anticipate BMI-related health conditions; and provide condition-specific support for women who encounter BMI-related health conditions. Based on the scope of this issue in North Carolina, programs and interventions should be targeted to women at least 20 years of age, women with an income of less than $50,000, WIC and Medicaid recipients and Black women.

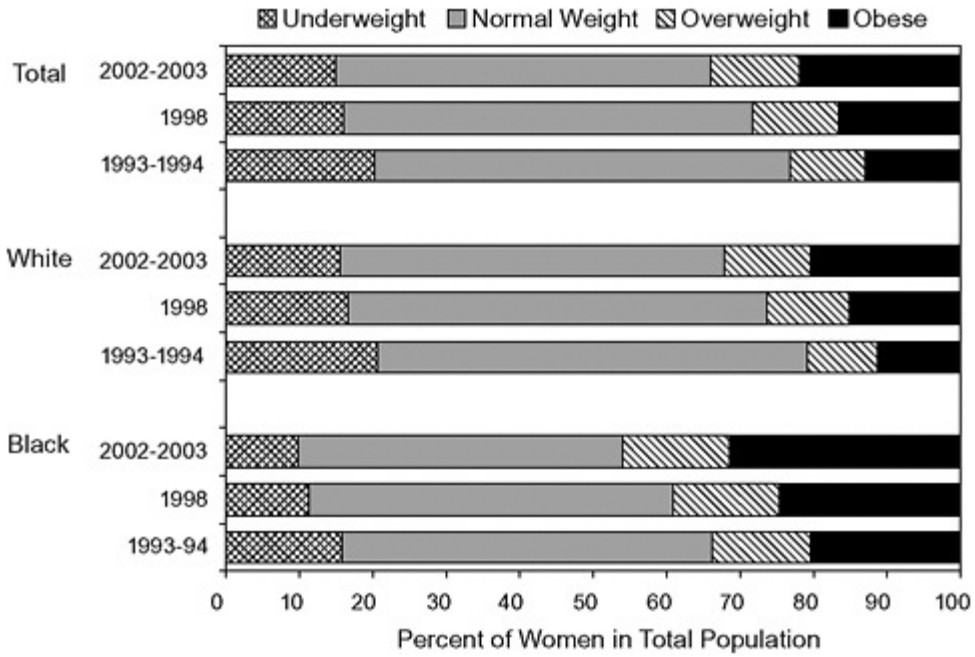
A fourth recommendation is to ameliorate HCP identified barriers. Boyle et al. (2009) notes that HCPs need support in both practice and advocacy efforts. Supporting HCPs in practice includes providing education on the issue, identifying time-efficient ways for them to address the issue with patients, funding prevention communication, addressing issues with insurance coverage, offering incentives, providing monitoring charts for BMI tracking, and equipping them with obesity prevention messages. Supporting HCPs in obesity advocacy involves training HCPs on how to conduct advocacy and policy work, providing a better understanding of how advocacy can

benefit communities and connecting HCPs to advocacy opportunities (Boyle et al., 2009).

Prevention is key to addressing the impact of maternal weight on pregnancy outcomes and ultimately infant mortality. Preconception efforts offer the best opportunity for prevention and HCPs hold an influential position in terms of prevention and preconception interventions. Therefore, supporting North Carolina's HCPs in obesity prevention is integral to improving North Carolina's infant mortality rate.

Figures and Tables

Figure 1. Trends in the Distribution of BMI from 1993 to 2003 among Prepregnant U.S. Women in the Total Population and by Race or Ethnicity.



(SOURCE: Kim et al. 2007)

Table 1. Body Mass Index (BMI) Category Comparison

BMI Categories	WHO	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al.,2003
Underweight	< 18.5	≤19.9	<20.0	< 20	<20.0	<18.5	<18.5	* ≤99 lbs
Normal	18.5 – 24.9	20–24.9	20.0–24.9	20 – 24.9	20.0 - 24.9	18.5–25	18.5-24.9	* 100–149 lbs
Overweight	25.0 – 29.9	25–29.9	25.0–29.9	25 – 29.9	25.0 - 29.9	25–30	25-29.9	* 150–199 lbs
Obese	≥30.0	30–39.9	≥30.0	30 – 34.9	≥30.0	>30	≥30	* 200–299 lbs
Morbidly Obese	N/A	40+	N/A	> 35	N/A	N/A	N/A	* ≥300 lbs

* These weight groups were not defined as underweight, normal, overweight, obese, or morbidly obese.
N/A = not applicable, lbs = pounds.

Table 2. Study Characteristics

Citation	Country	Type and Source of Cohort	Maternal Inclusion Criteria	Maternal Exclusion Criteria	Cohort Size	Analysis Method
Abenhaim, et al., 2007	Canada	Retrospective cohort study. The McGill Obstetrical and Neonatal Database.	All pregnancies at Royal Victoria Hospital for which BMI was available and which took place between April 1st 1987 and March 31st 1997.	Prepregnancy BMI unavailable.	18643	Unconditional logistic-regression analysis was used to evaluate the relationship between BMI category and obstetrical and neonatal outcome.
Baeten, et al., 2001	US	Retrospective; Washington State birth certificate (wt) and driver's license (ht).	Nulliparous women with a singleton pregnancy between 1992-1996.	Prepregnancy height and weight not available to calculate BMI.	96801	Multiple logistic regression analysis to evaluate the association between prepregnancy BMI and pregnancy complications and adverse pregnancy outcomes.
Bhattacharya, et al., 2007	UK	Retrospective; Aberdeen Maternity and Neonatal Databank.	Nulliparous women delivering singleton babies after 24 weeks gestation in Aberdeen between 1976 and 2005.	Women booked after 16 weeks or missing data.	24241	Obstetric and perinatal outcomes were compared by univariate and multivariate analyses.
Cnattingius, et al., 1998	Sweden	Retrospective, population based cohort; Sweden's birth register records.	Singleton birth from 1992 and 1992 in Sweden.	Prepregnancy BMI unavailable.	167750	Multiple logistic-regression analysis evaluates association between prepregnancy BMI and late fetal death, early neonatal death, preterm delivery, and delivery of a small-for-gestational-age infant.

Citation	Country	Type and Source of Cohort	Maternal Inclusion Criteria	Maternal Exclusion Criteria	Cohort Size	Analysis Method
Doherty, et al., 2006	Australia	Secondary analysis of randomized controlled trial; questionnaires and medical records evaluating the effectiveness of Doppler ultrasound in unselected pregnancies.	Gestational age between 16 and 20 weeks, proficiency in English sufficient to understand the implications of participation, and an expectation to deliver at King Edward Memorial Hospital.	Prepregnancy BMI unavailable.	2827	Univariate comparisons between the BMI groups; Cox proportional hazards regression; and logistic regression modeling.
Jensen, et al., 2003	Denmark	Historical cohort study; medical records for patients delivering at one of the four participating centers.	The first pregnancy for a patient from the time period January 1, 1992 to December 31, 1996 was included.	Women with gestational diabetes according to WHO criteria14 (2-hour glucose values ≥7.8 mmol/L); women receiving dietary treatment, underweight (BMI <18.5 kg/m2) women, those with missing data on weight and/or height; multiple gestation pregnancies, and women referred to the centers from other hospitals because of a well-defined chronic disease.	2459	Univariate and multivariate logistic regression analysis.

Citation	Country	Type and Source of Cohort	Maternal Inclusion Criteria	Maternal Exclusion Criteria	Cohort Size	Analysis Method
Rosenberg, et al., 2003	US	Population-based study; birth certificate data obtained from the New York City Department of Health, Office of Vital Statistics and Epidemiology.	Live singleton births whose certificates included maternal prepregnancy weight (unable to calculate BMI since height not available on birth certificate).	Missing data.	213208	Multiple logistic regressions.

Table 3. Adverse Outcomes Associated with Increased Prepregnancy Body Mass Index (BMI)

	Increased BMI Outcome	**Total**	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
	Maternal Outcomes During Pregnancy								
	Antenatal admission	1	X						
	Eclampsia	1		X					
	Gestational Diabetes Mellitus	5	X	X		X	X		X
	Gestational Hypertension	4	X		X	X	X		
	Preeclampsia	7	X	X	X	X	X	X	X
	Maternal Outcomes During Labor and delivery								
	C-section (regardless of reason)	6	X	X	X		X	X	X
	Induction of labor	3			X		X	X	
*	Perineal tear (obese)	1					X		
	Shoulder dystocia	1	X						
	Maternal Post-Partum Outcomes								
	Postpartum hemorrhage	3	X		X		X		
	Wound complications & infections	1	X						
	Fetal/Neonatal Outcomes								
*	Early neonatal death among nulliparous	1				X			
	Infant Death	1		X					
	Late fetal death	1				X			
	LBW, VLBW or SGA	1							X
	Macrosomia	5	X	X	X			X	X
	Neonatal Hypoglycemia	1					X		
	NICU admission	2	X						X
	Poor Apgars or resuscitation	2	X				X		
	Preterm delivery	3	X	X	X				

* means that results discrepant between the 7 studies

NICU= neonatal intensive care unit, LBW = low birth weight, VLBW= very low birth weight, SGA= small for gestational age.

Table 4. Adverse Outcomes Associated with Decreased Prepregnancy Body Mass Index (BMI)

Decreased BMI Outcome	**Total**	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
Fetal/Neonatal Outcomes								
IUGR	2	X				X		
Low birth weight	2			X				X
Preterm delivery	1	X						
Preterm Labor	1	X						
SGA	2	X			X			

IUGR= intrauterine growth restriction, SGA = small for gestational age

Table 5. Odds Ratios for Adverse Pregnancy Outcomes

Increased BMI Outcome	BMI Category	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
Maternal Outcomes During Pregnancy								
Antenatal admission	overweight	1.15 (1.04-1.26)	--	--	--	--	--	--
	obese	1.82 (1.59-2.09)	--	--	--	--	--	--
	morbidly obese	2.98 (2.00-4.43)	--	--	--	--	--	--
Eclampsia	overweight	--	1.4 (1.0-2.0)	--	--	--	--	--
	obese	--	2.0 (1.4-2.9)	--	--	--	--	--
	morbidly obese	--	3.0 (2.1-4.4)	--	--	--	--	--
Gestational diabetes	overweight	1.89 (1.63–2.19)	1.3 (1.1-1.5)	--	np	2.71 (1.32-5.55)	--	2.1 (2.0-2.2)
	obese	3.22 (2.68–3.87)	2.4 (2.0-2.9)	--	--	6.5 (3.32-12.74)	--	4 (3.7-4.3)
	morbidly obese	4.71 (2.89–7.67)	5.2 (4.3-6.2)	--	--	N/A	--	5.2 (3.8-7.2)
Gestational hypertension	overweight	1.56 (1.35–1.81)	--	1.5 (1.4-1.7)	np	2.6 (1.49-4.55)	--	--
	obese	2.01 (1.64–2.45)	--	2.2 (2.1-2.6)	--	7.3 (4.74-13.27)	--	--
	morbidly obese	2.77 (1.60–4.78)	--	3.1 (2.0-4.3)	--	N/A	--	--
Preeclampsia	overweight	2.28 (1.88-2.77)	1.3 (1.2-1.5)	1.6 (1.2-1.8)	np	NSS	NSS	1.6 (1.5-1.7)

Increased BMI Outcome	BMI Category	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
	obese	4.65 (3.71-5.83)	2 (1.8-22)	3.1 (2.8-3.5)	--	3.74 (1.95-7.17)	5.6 (3.5-9.0)	2.6 (2.4-2.9)
	morbidly obese	6.26 (3.48-11.26)	3.3 (3.0-3.7)	7.2 (4.7-11.2)	--	N/A	N/A	5 (3.5-7.1)
Maternal Outcomes During Labor and delivery								
C-section	overweight	1.48 (1.35–1.62)	1.3 (1.2-1.3)	EL NSS EM 1.5 (1.3-1.6)	--	all 1.39 (1.04-1.86) EM NSS	1.6 (1.3-2.3)	1.4 (1.3-1.4)
	obese	1.85 (1.62–2.11)	1.8 (1.6-1.9)	EL NSS EM 2 (1.8-2.3)	--	all 2.22 (1.58-3.12) EM 4.57 (2.22-9.41)	2.7 (1.9-3.8)	2.1 (2.0-2.2)
	morbidly obese	2.92 (1.97–4.34	2.7 (2.5-2.9)	EL 3.1 (1.7-6.1) EM 2.8 (2.0-3.9)	--	N/A	N/A	2.7 (2.2-3.4)
Induction of labor	overweight	1.21 (1.10-1.32)	--	1.3 (1.2-1.4)	--	1.36 (1.05-1.77)	1.5 (1.1-2.2)	--
	obese	1.6 (1.40-1.82)	--	1.8 (1.6-2.0)	--	2.44 (1.72-3.45)	3.2 (2.2-4.6)	--
	morbidly obese	2.06 (1.38-3.07)	--	1.8 (1.3-2.5)	--	N/A	N/A	--
* Perineal tear (obese)	overweight	--	--	--	--	NSS	--	--
	obese	--	--	--	--	1.59 (1.08-2.33)	--	--
	morbidly obese	--	--	--	--	N/A	--	--
Shoulder dystocia	overweight	1.50 (1.37-1.65)	--	--	--	--	--	--

Increased BMI Outcome	BMI Category	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
	obese	1.89 (1.65-2.16)	--	--	--	--	--	--
	morbidly obese	NSS	--	--	--	--	--	--
Maternal Post-Partum Outcomes								
Postpartum hemorrhage	overweight	1.26 (1.03-1.55)	--	NSS	--	1.55 (1.17-2.06)	--	--
	obese	NSS	--	1.5 (1.3-1.7)	--	1.71 (1.20-2.44)	--	--
	morbidly obese	3.14 (1.65-5.97)	--	NSS	--	N/A	--	--
Wound complications/ infections	overweight	NSS	--	--	--	--	--	--
	obese	2.69 (1.34-5.38)	--	--	--	--	--	--
	morbidly obese	6.41 (1.85-22.19)	--	--	--	--	--	--
Fetal/ Neonatal Outcomes								
Early neonatal death among nulliparous	overweight	--	--	--	np	--	--	--
	obese	--	--	--	np	--	--	--
	morbidly obese	--	--	--	np	--	--	--
Infant death	overweight	--	NSS	--	--	--	--	--
	obese	--	NSS	--	--	--	--	--
	morbidly obese	--	2.0 (1.2-3.1)	--	--	--	--	--
Late fetal death	overweight	--	--	--	NSS	--	--	--
	obese	--	--	--	1.7 (1.1-2.4)	--	--	--

Increased BMI Outcome	BMI Category	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
	morbidly obese	--	--	--	2.7 (1.8-4.1)	--	--	--
LBW, VLBW or SGA	overweight	--	--	--	--	--	--	VLBW 1.2 (1.1-1.3)
	obese	--	--	--	--	--	--	VLBW 1.3 (1.1-1.6)
	morbidly obese	--	--	--	--	--	--	NSS
Macrosomia	overweight	1.66 (1.23-2.24)	1.2 (1.2-1.3)	1.4 (1.3-1.6)	--	--	NSS	2.0 (1.9-2.1)
	obese	2.32 (1.58-3.41)	1.5 (1.4-1.6)	1.9 (1.6-2.2)	--	--	LGA 2.5 (1.8-3.6) >4kg 2.2 (1.6-3.1)	3.1 (2.9-3.3)
	morbidly obese	NSS	2.1 (1.9-2.4)	2.1 (1.3-3.2)	--	--	N/A	3.8 (2.8-5.1)
Neonatal hypoglycemia	overweight	--	--	--	--	1.91 (1.19-3.06)	--	--
	obese	--	--	--	--	NSS	--	--
	morbidly obese	--	--	--	--	N/A	--	--
NICU admission	overweight	1.21 (1.08-1.36)	--	--	--	--	--	1.1 (1.0-1.1)
	obese	1.60 (1.37-1.87)	--	--	--	--	--	1.1 (1.0-1.2)
	morbidly obese	2.89 (1.89-4.42)	--	--	--	--	--	1.5 (1.0-2.2)
Poor Apgar or resuscitation	overweight	1.70 (1.30-2.70)	--	--	--	1.3 (1.01-1.67)	--	--
	obese	3.18 (2.11-4.81)	--	--	--	1.75 (1.26-2.43)	--	--

	Increased BMI Outcome	BMI Category	Abenhaim et al., 2007	Baeten et al., 2001	Bhattacharya et al., 2007	Cnattingius et al., 1998	Doherty et al., 2006	Jensen et al., 2003	Rosenberg et al., 2003
		morbidly obese	6.00 (2.66-13.37)	--	--	--	N/A	--	--
*	Preterm delivery	overweight	32-36 wks 1.2 (1.04-1.38) <32wks NSS	<37wks NSS ≤32 wks NSS	NSS	--	--	--	--
		obese	32-26 wks 1.6 (1.32-1.94)	NSS	NSS	--	--	--	--
		morbidly obese	32-26 wks 2.43 (1.46-4.05)	≤32wks 1.5 (1.1-2.1)	1.2 (1.1-2.8)	--	--	--	--

* results discrepant between the 7 studies

Decreased BMI Outcome	BMI Category	ABENHAIM, et al., 2007	BAETEN et al, 2001	BHATTACHARYA, et al., 2007	CNATTINGIUS et al, 1998	DOHERTY, et al, 2006	JENSEN, et al., 2003	ROSENBERG, et al., 2003
Maternal Labor and Delivery Outcomes								
Preterm Labor	Underweight	1.22 (1.09-1.37)	--	--	--	--	--	--
Preterm Birth	Underweight	--	--	1.4 (1.1-1.9)	--	--	--	--
Fetal Outcomes								
IUGR	Underweight	1.33 (1.07-1.67)	--	--	--	1.8 (1.26-2.56)	--	--
LBW or VLBW	Underweight	--	--	1.7 (1.2-2.0)	--	--	--	1.4 (1.1-1.8)
SGA	Underweight	1.54 (1.37-1.72)	--	--	np	--	--	--

SGA= small for gestational age, IUGR= intrauterine growth restriction, VLBW= very low birth weight, LBW= low birth weight, N/A= not applicable, wks= weeks, EL= elective, LGA= larger for gestational age, EM= emergency, NSS= not statistically significant, np= not provided.

Table 6. Additional Adverse Outcomes Noted in Ineligible Articles

Outcomes associated with increased prepregnancy body mass index	
Maternal	**Fetal**
Maternal Outcomes During Pregnancy Antenatal admission Eclampsia Gestational Diabetes Gestational Hypertension Preeclampsia Maternal Outcomes During Labor or Delivery c-section (regardless of reason) induction of labor perineal tear preterm delivery * shoulder dystocia Maternal Post-Partum Outcomes decreased duration of breastfeeding later onset of lactogenesis II postpartum endometriosis postpartum hemorrhage prolonged hospital stay wound complications & infections	Anencephaly Birth trauma Breastfeeding issues Early neonatal death among nulliparous High birth weight Late fetal death Macrosomia Neural tube defects NICU admission Preterm labor * Poor Apgars/ resuscitation Spina bifida
*= disagreement between various articles about the significance of this outcome	

Outcomes associated with Decreased prepregnancy body mass index	
Maternal	**Fetal**
Preterm birth * Preterm labor * Protective effects on other complications	Intrauterine growth restriction Low birth weight/Very low birth weight Small for gestational age
*= disagreement between various articles about the significance of this outcome	

Table 7. 2007 Population Estimate for North Carolina Females of Childbearing Age

July 1, 2007 County Total Age Groups - Females

County	15	16-17	18-19	20-24	25-34	35-44	Total	Median Age (All females)
Alamance	976	1,986	2,532	5,082	8,597	10,638	29,811	38.98
Alexander	250	450	469	1,135	2,075	2,798	7,177	40.08
Alleghany	69	127	122	292	569	679	1,858	46.1
Anson	153	368	333	863	1,371	1,607	4,695	39.54
Ashe	132	292	285	717	1,344	1,687	4,457	45.21
Avery	103	192	243	591	878	1,051	3,058	42.88
Beaufort	303	608	602	1,491	2,518	2,856	8,378	42.79
Bertie	159	288	298	763	1,118	1,297	3,923	41.53
Bladen	191	434	401	1,083	1,860	2,067	6,036	40.61
Brunswick	655	1,328	1,297	2,873	5,776	7,135	19,064	42.32
Buncombe	1,380	2,861	2,759	6,705	14,169	16,185	44,059	42
Burke	582	1,195	1,210	2,777	4,596	6,055	16,415	41.4
Cabarrus	1,178	2,398	2,277	5,089	9,992	12,940	33,874	37.89
Caldwell	510	1,019	1,004	2,355	4,364	5,812	15,064	40.92
Camden	72	143	150	324	549	723	1,961	40.68
Carteret	381	785	763	1,990	3,100	4,145	11,164	45.54
Caswell	159	310	283	747	1,138	1,528	4,165	43
Catawba	1,031	2,098	2,054	4,624	9,306	11,196	30,309	39.18
Chatham	373	748	745	1,667	3,279	4,397	11,209	41.47
Cherokee	168	312	310	822	1,436	1,676	4,724	45.58
Chowan	110	218	219	542	771	885	2,745	43.09
Clay	56	110	123	304	522	613	1,728	47.9
Cleveland	725	1,474	1,548	3,213	5,775	6,934	19,669	39.76
Columbus	338	732	733	1,961	3,133	3,499	10,396	39.64
Craven	607	1,246	1,271	3,542	5,237	5,818	17,721	37.03
Cumberland	2,316	4,708	4,712	12,199	21,654	23,321	68,910	32.95
Currituck	178	353	363	827	1,336	1,848	4,905	40.44
Dare	207	417	450	997	1,590	2,371	6,032	43.82
Davidson	1,071	2,192	2,106	4,967	8,756	11,993	31,085	40.47
Davie	290	570	532	1,278	2,194	3,005	7,869	41.28
Duplin	349	720	709	1,684	3,114	3,445	10,021	37.7
Durham	1,534	3,183	4,403	11,423	19,218	18,480	58,241	34.44
Edgecombe	339	756	801	1,839	3,004	3,488	10,227	40.09
Forsyth	2,286	4,669	4,389	9,906	22,704	26,052	70,006	38.87
Franklin	403	833	806	1,766	3,320	4,448	11,576	38.89
Gaston	1,410	2,953	2,736	6,268	12,158	15,460	40,985	39.09
Gates	99	193	196	440	581	905	2,414	41.03
Graham	51	114	95	243	426	515	1,444	43.79
Granville	403	750	693	1,605	2,755	3,938	10,144	40.1
Greene	146	294	263	679	1,214	1,351	3,947	39.24
Guilford	3,095	6,418	8,304	17,255	28,957	35,896	99,925	38
Halifax	399	885	791	2,010	3,099	3,572	10,756	41.1

July 1, 2007 County Total Age Groups - Females

County	15	16-17	18-19	20-24	25-34	35-44	Total	Median Age (All females)
Harnett	790	1,623	1,792	3,987	6,909	8,269	23,370	35.67
Haywood	360	676	754	1,697	2,845	3,986	10,318	45.29
Henderson	609	1,256	1,240	2,862	5,227	6,922	18,116	44.14
Hertford	179	372	431	926	1,498	1,586	4,992	41.23
Hoke	342	702	651	1,406	2,917	3,429	9,447	33.23
Hyde	36	74	60	146	179	284	779	46.24
Iredell	1,097	2,245	2,111	4,702	8,814	11,744	30,713	39.06
Jackson	201	404	1,171	2,152	1,935	2,130	7,993	38.42
Johnston	1,141	2,253	2,072	4,530	9,419	13,299	32,714	37.54
Jones	83	151	154	365	469	658	1,880	43.51
Lee	357	765	749	1,785	3,336	3,838	10,830	37.76
Lenoir	364	766	753	1,923	3,137	3,651	10,594	42.09
Lincoln	523	1,089	1,006	2,234	4,107	5,571	14,530	39.38
Macon	202	402	393	1,015	1,645	2,146	5,803	46.37
Madison	125	265	381	656	1,097	1,430	3,954	42.18
Martin	172	343	334	884	1,306	1,598	4,637	41.81
Mcdowell	271	575	553	1,323	2,531	2,942	8,195	41.24
Mecklenburg	6,106	12,335	11,483	24,538	58,585	75,690	188,737	36.66
Mitchell	93	216	204	485	765	1,045	2,808	45.4
Montgomery	161	375	316	852	1,603	1,581	4,888	38.86
Moore	531	1,144	1,051	2,601	4,297	5,636	15,260	43.76
Nash	708	1,371	1,308	3,086	5,557	6,741	18,771	39.3
New Hanover	1,131	2,318	3,413	7,748	12,020	14,251	40,881	38.93
Northampton	130	323	300	766	1,025	1,283	3,827	44.16
Onslow	1,026	2,102	2,940	8,351	10,664	10,681	35,764	28.04
Orange	741	1,553	5,101	8,489	8,343	8,893	33,120	34.28
Pamlico	66	145	145	386	537	661	1,940	47.66
Pasquotank	298	607	796	1,731	2,382	2,806	8,620	38.07
Pender	346	709	654	1,518	2,755	3,618	9,600	41.52
Perquimans	83	159	195	451	672	841	2,401	43.79
Person	257	541	509	1,178	2,063	2,737	7,285	41.46
Pitt	1,036	2,061	4,498	9,584	9,695	11,126	38,000	33.55
Polk	125	236	245	539	886	1,197	3,228	47.23
Randolph	940	1,958	1,876	4,340	7,827	10,416	27,357	39.44
Richmond	345	669	628	1,543	2,741	3,098	9,024	38.76
Robeson	975	2,027	2,086	4,893	8,393	8,676	27,050	34.51
Rockingham	601	1,175	1,204	2,782	5,039	6,495	17,296	42.04
Rowan	904	1,907	1,939	4,529	8,075	9,534	26,888	39.39
Rutherford	463	869	832	2,000	3,627	4,406	12,197	41.07
Sampson	438	934	826	1,997	3,907	4,277	12,379	37.69
Scotland	289	584	561	1,434	2,509	2,568	7,945	37.17
Stanly	384	801	821	1,983	3,283	3,903	11,175	40.22
Stokes	326	641	625	1,439	2,590	3,701	9,322	41.11
Surry	460	973	946	2,079	3,972	5,119	13,549	41.42
Swain	90	215	212	459	793	930	2,699	40.69
Transylvania	189	341	353	995	1,755	1,838	5,471	46.47
Tyrrell	30	32	47	133	158	225	625	44.39

July 1, 2007 County Total Age Groups - Females

County	15	16-17	18-19	20-24	25-34	35-44	Total	Median Age (All females)
Union	1,400	2,853	2,593	5,504	11,182	15,185	38,717	36.72
Vance	347	678	632	1,482	2,703	3,112	8,954	37.71
Wake	6,001	11,989	11,706	26,792	57,067	71,180	184,735	36.49
Warren	118	289	267	688	931	1,174	3,467	44.35
Washington	94	223	188	528	645	841	2,519	41.55
Watauga	193	368	2,136	3,912	2,202	2,288	11,099	33.24
Wayne	791	1,625	1,608	3,984	7,171	7,918	23,097	37.63
Wilkes	410	850	830	2,009	3,697	4,655	12,451	41.98
Wilson	563	1,149	1,106	2,545	4,870	5,494	15,727	38.88
Yadkin	253	546	492	1,119	1,994	2,859	7,263	41.03
Yancey	104	229	240	513	924	1,172	3,182	45.21
State	61,635	125,811	136,897	311,516	556,828	677,643	1,870,330	38.28

Last updated 24APR2009

http://www.osbm.state.nc.us/ncosbm/facts_and_figures/socioeconomic_data/population_estimates.shtm

Table 8. 2007 North Carolina Pregnancy Risk Assessment Monitoring System Survey Results

MATERNAL CHARACTERISTICS
Mother's Body Mass Index (BMI) Before Pregnancy*

Demographic Groups	Total Respond.#	Underweight (<18.5)			Normal (18.5-24.9)			Total Overweight (>=25.0)		
		N	%	C.I. (95%)	N	%	C.I. (95%)	N	%	C.I. (95%)
Total	1557	79	4.6	3.5- 6.1	805	52.1	49.0-55.3	673	43.3	40.2-46.4
Age										
< 20 years	184	19	8.5	4.6-15.3	105	58.5	48.9-67.4	60	33.0	24.8-42.5
20-24 years	370	28	6.2	3.8-10.0	179	47.5	41.1-53.9	163	46.3	40.0-52.7
25-34 years	782	28	3.6	2.3- 5.6	409	53.2	48.8-57.5	345	43.2	38.9-47.7
35+ years	221	4	1.7	0.5- 5.8	112	51.4	43.2-59.6	105	46.8	38.8-55.1
Race										
White	1047	57	4.6	3.3- 6.4	579	56.0	52.3-59.6	411	39.4	35.8-43.1
Black	440	18	4.6	2.5- 8.4	189	42.4	36.2-48.9	233	53.0	46.5-59.3
Other	70	4	4.4	1.3-14.0	37	46.3	32.6-60.6	29	49.3	35.3-63.4
Hispanic origin										
Yes	118	5	4.9	1.9-12.0	55	47.5	37.4-57.9	58	47.6	37.5-58.0
No	1436	74	4.6	3.4- 6.2	747	52.6	49.3-55.9	615	42.8	39.6-46.1
Education										
< High School	259	20	6.0	3.2-10.8	125	47.1	39.3-55.0	114	47.0	39.2-54.9
High School	438	25	4.5	2.6- 7.8	207	48.8	42.9-54.7	206	46.7	40.8-52.6
> High School	854	34	4.2	2.8- 6.2	470	56.0	51.8-60.1	350	39.8	35.8-44.0
Marital Status										
Married	962	41	3.7	2.5- 5.4	512	55.0	51.1-58.8	409	41.3	37.6-45.2
Other	595	38	6.0	3.9- 9.0	293	47.9	42.6-53.2	264	46.2	41.0-51.5

Demographic Groups	Total Respond.#	Underweight (<18.5)			Normal (18.5-24.9)			Total Overweight (>=25.0)		
		N	%	C.I. (95%)	N	%	C.I. (95%)	N	%	C.I. (95%)
Income										
14,999 or less	391	28	5.3	3.1- 9.0	173	44.8	38.4-51.3	190	49.9	43.4-56.4
15,000-24,999	238	20	9.5	5.6-15.5	112	46.6	38.5-54.8	106	43.9	36.0-52.2
25,000-49,999	302	14	3.6	1.8- 7.1	143	45.0	38.1-52.1	145	51.4	44.4-58.5
50,000 or more	535	13	2.5	1.3- 4.7	323	61.7	56.6-66.6	199	35.8	31.1-40.9
WIC recipient										
No	919	35	3.5	2.3- 5.4	526	58.9	54.9-62.8	358	37.6	33.7-41.6
Yes	622	44	6.2	4.2- 9.1	275	43.2	38.3-48.2	303	50.6	45.6-55.6
Medicaid recipient										
No	775	23	2.6	1.5- 4.3	447	58.9	54.5-63.1	305	38.6	34.4-42.9
Yes	782	56	6.5	4.6- 9.1	358	45.8	41.4-50.4	368	47.7	43.2-52.2
Infant's birth weight										
Under 2500 grams	719	42	6.1	4.6- 8.1	358	49.2	45.6-52.7	319	44.7	41.2-48.3
2500+ grams	838	37	4.5	3.2- 6.1	447	52.4	49.0-55.8	354	43.1	39.8-46.5

*Data in this table are constructed from survey questions 5 and 6. (BMI is a relationship between weight and height that is associated with body fat and health risk.)

#Use caution in interpreting cell sizes less than 50.
N = Cell Size, % = Percentage, C.I. (95%) = Confidence Interval (at 95 % probability level), WIC = .Supplemental Nutrition Program for Women, Infants and Children.
The percentages shown are weighted percentages, designed to reflect the entire population of North Carolina women having a live birth.

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Table 9. Measuring Association between Maternal Characteristics and Overweight: 2007 North Carolina PRAMS data

Demographic Groups	Total Respond. #	Total Overweight (>=25.0) N	Overweight Odds Ratio	LCI	UCI
Total	1557	673			
Age					
< 20 years	184	60	1		
20-24 years	370	163	1.63*	1.12	2.36
25-34 years	782	345	1.63*	1.16	2.29
35+ years	221	105	1.87*	1.25	2.81
Race					
White	1047	411	1		
Black	440	233	1.74*	1.39	2.18
Other	70	29	1.09	0.67	1.79
Hispanic origin					
Yes	118	58	1		
No	1436	615	0.78	0.53	1.13
Education					
< High School	259	114	1.13	0.86	1.50
High School	438	206	1.28	1.01	1.61
> High School	854	350	1		
Marital Status					
Married	962	409	1		
Other	595	264	1.08	0.88	1.33
Income					
14,999 or less	391	190	1.6*	1.22	2.08
15,000-24,999	238	106	1.36	0.99	1.85
25,000-49,999	302	145	1.56*	1.17	2.08
50,000 or more	535	199	1		
WIC recipient					
No	919	358	1		
Yes	622	303	1.49*	1.21	1.83
Medicaid recipient					
No	775	305	1		
Yes	782	368	1.37*	1.12	1.68
Infant's birth weight					
Under 2500 grams	719	319	1.09	0.89	1.33
2500+ grams	838	354	1		

**denotes statistically significant for overweight*
N= number , LCI= lower confidence interval value , UCI= upper confidence interval value , WIC= Supplemental Nutrition Program for Women, Infants, and Children.

Table 10. Frequency of HCP Reported Barriers to Diagnosing and Managing Overweight/Obesity

HCP reported Barriers	Frequency
HCP factors	
–Lack of time to counsel	8
–Lack of knowledge/confidence	8
–Fear of embarrassing patient	2
–Frustration from prior attempts	1
–Forgetting to talk about it or document it/ complacency	2
–Perception of patient motivation/compliance	7
–Lack of belief the treatment will be effective	5
Patient factors	
–Frustration from prior attempts	1
–Lack of motivation	1
–Lack of knowledge	1
–Lack of family or community support	1
–Fear of embarrassment	1
–Cost concerns	1
Environmental and cultural factors	
–Cultural practices	1
–Social or family support	1
–Environmental milieu	3
Economic factors	
–Patient costs	1
–Direct obesity care, comorbidities	1
–Health care system costs	1
Allied health care factors	
–Nonreferral to dietitian	1
–Patients not informed of BMI	1
–Limited time to counsel	1
Medical system factors	
–Limited resources	4
–Higher initial cost of clinic visits	1
–Insurance or Medicare reimbursement issues	6
–Patient or physician not informed of BMI at office visits	1

Based on Bardia et al.'s barriers to optimal obesity management (Bardia et al., 2007)

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